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CURRENT NOTES.

FOREST-CULTURE IN SWITZERLAND.—From a report by Consul Adams on Forestry in the Canton of Vaud, and published by the Department of State, we learn that the culture of forests is carried on by the canton with a profit of nearly 70 per cent. The method followed in renewing the forests varies with the altitude, the character and exposure of the soil, the species of plants, etc. Wherever the forest renews itself naturally, as after clearing or trimming, planting is resorted to only to fill vacant spaces. Wherever portions of the forests have been felled replanting is necessary. The shoots used are reared in the state nurseries, then transplanted, and finally, two, three, or even four years after the first transplantation, are set out in the forest, usually in the spring. The plants are separated from each other 3 feet 3 inches, the rows 3 feet 3 inches, 3 feet 11 inches, or even 4 feet 11 inches. The mingling of different species is recommended. No bounties are offered for planting, but the Confederation grants a subvention of 30 to 40 per cent. of the cost of new forests at an altitude greater than 1,000 meters (3,280 feet).

Considerable injury is done to the cultivated forests by insects, fungi, and storms. From 1870 to 1875 the ravages of the *Bostrichus typographus* necessitated the felling of several thousand trees of the resinous genus *Picea* growing in the uplands, and the burning of the bark. This was done so thoroughly that the insect appears to have been extirpated, and has been little heard of since 1875. The hurricanes which swept over

Switzerland February 20, June 25, and December 5, 1879, were very destructive in parts of the canton. The loss in trees broken, overthrown, or uprooted was estimated at more than 150,000 cubic meters of wood. In 1884 and 1885 premature snowfalls prostrated great numbers of young oak and other deciduous trees which had not shed their foliage. The forest bureau is doing what it can to avert similar disasters by prescribing or urging the use of hardier plants, a judicious mixture of species, and careful clearing and trimming of the trees.

But perhaps the most interesting facts given by Consul Adams are those relating to the reclamation of waste lands.

The increasing value of wood, the evident effect of forests on conditions of climate, and subsidies of the Federal Government for new forests, have greatly encouraged the planting of movable soils in the mountains, and of marshes in the uplands and plains. So, too, considerable tracts, exposed by the partial draining of the lakes of Neuchatel and Morat, have been wooded by the state in the expectation that the pure sand now composing the soil will be fitted in time for more useful growths. It is found that shifting sands of this description are wooded more rapidly and with the best effects by the alder and poplar. In general, movable soils must first be stayed by *clayonnage* (interlaced branches held by posts driven into the soil) and then planted with trees which take wide and deep root, and whose dense foliage shelters the soil from heavy rains. The species recommended are the acacia, alder, maple, willow, oak, and others.

EVAPORATION EXPERIMENTS.–During the past year experiments on evaporation from the surface of earth and from water were made at Rousdon Observatory, Devon, England. The apparatus, we learn from Mr. Peek's report, consisted of two precisely similar iron tanks, 2 feet square and 15 inches deep, freely exposed to the air and protected from the rays of the sun by a louvred wooden frame. The tank containing the earth was placed on a weighing machine, the bottom 2 feet six inches from the ground. The earth was ordinary soil, turfed over so as

to represent meadow land. At the bottom of the tank a tap was placed in order that the surplus water might be drawn off and weighed.

The water tank was at equal height and in all respects similar, except that an overflow pipe was placed so as to maintain the water at a uniform depth of 12 inches. The earth tank was weighed daily and the water tank measured on the first day of each month, a careful record being kept of the water added or drawn off in the interval when necessary for maintaining the standard depth of 12 inches.

	Earth Tank		Water Tank.	
1886.	Total Evaporation.	Mean Daily Evaporation.	Total Evaporation.	Mean Daily Evaporation.
	Inches	Inches.	Inches.	Inches.
January	0.29	0.01	1.36	0.01
February	0.53	0.02	0.82	0.03
March	1.29	0.04	1.28	0.04
April	2.95	0.10	2.49	0.08
May	3.38	0.11	2.86	0.09
June	4.43	0.15	3.61	0.12
July	2.96	0.10	3.72	0.12
August	2.40	0.08	2.78	0.09
September	2.04	0.07	1.81	0.06
October	2.15	0.07	1.41	0.05
November	1.02	0.03	0.72	0.02
December	1.35	0.04	0.95	0.03
For Year	24.79	0.07	22.81	0.09

METEOROLOGICAL NOTES.—The *Daily Telegraph* of St. John, N. B., publishes an elaborate monthly weather review.—Mr. C. Leeson Prince, F. R. A. S., F. R. Met. S., etc., continues his reports from his private observatory at Crowborough, Sussex, England. We have before us his report for 1886, with a review of the weather of the year. The observatory is 825 feet above sea-level, in latitude 51° 3′, longitude 0° 9′ 30″ east.—The *Sanitary News* of Chicago contained (Feb. 19, 1887) in a discussion of the Chicago sewerage and water supply, a reproduction of an automatic register of changes in the level of Lake Michigan, for August 16th, 1886. Fluctuations of from six inches to two and a half feet occurred at not very irregular intervals of about an

hour. We are glad to see that Dr. Draper's Thermographs can now be obtained without trouble. They are manufactured by the Draper Manufacturing Company, 152 Front St., New York. —Dr. Doberck's annual report is entitled *Observations and Researches made at the Hong Kong Observatory in the year 1886*, and is printed at Hong Kong. It contains the monthly reports, the summaries and means of the observations taken during the year, and the special reports made from time to time, the most of which have been already mentioned in these columns. It is a valuable publication of several hundred pages and could probably be obtained by applying directly to Dr. Doberck.–The annual report of Mr. Cuthbert E. Peek, M. A., F. R. Met. S., F. R. A. S., etc., of Meteorological Observations at the Rousdon Observatory, Devon, is at hand. The Observatory is in latitude 50° 42′ longitude 3° 0′ W.; altitude 524 feet above sea-level. The postal address is Lyme Regis, Dorset, England. We give elsewhere the evaporation experiments carried on at this observatory.—The motto preceding Mr. Peek's report reminds us of the "Beehive" or "Presepe," the use of which for predicting the weather seems to have not been adopted on the new continent in the very latitudes in which it was used on the old. The motto is from Aratus (B. C. 270) and runs.

> Look in fair weather for signs of foul,
> For signs of calm in storm; and ever closely
> Inspect the Manger encompassed by the Crab;
> When first it purges off its misty gloom.
> For as the Manger clears, so wanes the tempest.

There is certainly something curious in the varying visibility of this interesting cluster—a variability which undoubtedly depends only on our own atmosphere. Presepe can sometimes be clearly seen when the neighboring bright stars are nearly blotted out by cloud or fog; and, on the other hand, it is sometimes quite faint when the sky seems unusually clear.

NOTES FROM THE PILOT-CHART.—*Water-spouts* are not usually considered dangerous but the following reports from three successive issues of the Pilot-Chart show that they may be otherwise.

Captain Scott, of the British bark Autocrat, reports that on January 14, in latitude 32° 13′ N., longitude 76° 09′ W., his vessel was struck by a water-spout, which split lower maintop-sail, started main hatch combings, chain locker and water casks, and threw the vessel on her beam ends.

The bark Winonah was struck by a water-spout on February 9, in latitude 22° 00′ N., longitude 40° 00′ W., and had all her yards broken.

Captain Arey, of the schooner Jose Olaverri, reports that on March 25, in latitude 36° 00′ N., longitude 61° 20′ W., the wind being strong from SW., with dark, gloomy, squally weather, he observed a black cloud in the SW., and apparently close to the vessel. Kept her off, but in an instant she was struck amidships by a large water-spout, which tore the fore and main sails badly and flooded the decks.

Valuable information concerning *currents* can be deduced by the float of bodies whose departure and arrival can be timed and located. We will let our readers work out on their own atlases the probable journey in the following cases:

A bottle was thrown overboard from the schooner Emma L. Cottingham, Captain Somers, on July 20, 1886, in latitude 41° 06′ N., longitude 69° 08′ W. It was found on January 29, between Micommet and Miox ponds, on the south side of Nantucket, and was forwarded to the Hydrographic Office by Mr. James C. McCleave.

A bottle was picked up at Warnambool, Australia, on January 2, which contained a paper stating that it was thrown overboard from the ship Patriarch, on July 22, 1886, in latitude 37° 29′ N., longitude 126° 50′ E.

A bottle was picked up at Winding bay, Great Abaco island, on February 4, which contained a paper stating that it was thrown overboard from the ship Patrician, on December 19, 1885, in latitude 19° 33′ N., longitude 35° 35′ W.

A bottle was picked up on the south end of the island of Flores, Azores, on February 21, which contained a paper stating that it was thrown overboard from the ship Patriarch, on January 11, in latitude 39° 15′ N., longitude 32° 19′ W.

Captain Basham, of the British brig Mississippi, seems to have met with a *tornado* on the east coast of South America. He reports that at 6 P. M., February 15, in latitude 25° 11′ S., longitude 44° 52′ W., he had fine weather with light breeze from north. At 6:30 the weather suddenly changed, a dark lead-colored cloud descended from the zenith and burst over the vessel with great violence; the wind and rain struck the water about a ship's length away on the port side, raising a cloud of salt spray, and carrying the fore-topgallant mast, royal and topgallant yards and jibboom over the side before the vessel could be got before the wind. The squall obtained about a force of 9. but did not last more than 4 minutes, and was followed by a calm lasting all night.

The annual southerly *movement of the ice* in the western part of the North Atlantic began unusually early this year, and reports received during March indicated that heavy bodies of field ice and numerous bergs were moving south along the eastern edge of the Grand Banks. From observations of the temperature of the sea water it has been found that the polar current pushes farther south, by two or three degrees, between longitudes 48° and 50° than it does elsewhere in this neighborhood, and therefore the extreme southern limit of ice should be found between these meridians. Many vessels were reported injured by ice during March. In April there was an unusual amount of field ice off the coast of Nova Scotia. The British bark Susan was sunk by collision with an iceberg on April 2, off Tennessee head, Newfoundland.

The Hydrographic office still continues to collect evidence showing the *value of oil* in preventing breaking seas. As might be expected the oil is of especial use to heavily laden small boats which must be used when a vessel must be abandoned. It is curious that no novelist, so far as known to the writer, has ever thought of this way of saving his hero. The actual use is illustrated in the following report in which the testimony to the value of oil as a safeguard to life and property at sea cannot fail to be convincing to the most skeptical. It is furnished by Mr. Carmichael, at present serving as quartermaster on board the

British steamer "Istrian:" "In 1885 was serving as a seaman on board the British ship 'Slivemore,' bound from Shields to Bombay. In June of the above year, when about 800 miles to the northward and eastward of the Seychelle islands, the vessel took fire and had to be abandoned. The people took to the boats and made for the Seychelles. The third day after leaving the vessel a cyclone was encountered, and nobody believed for an instant that the boats would live through it. Before leaving the ship the captain had taken the precaution to supply the boats with oil, with a view to just such an emergency as had now arisen. Each boat got out a drag, consisting of spars and oars lashed together, and used oil as follows: A long stocking was stuffed with oakum saturated with paraffine and hung over the bows of the boats. Previously to using the oil the boat had been several times nearly filled with water, so that the occupants had to bail for their lives. After the use of oil was begun no further trouble was experienced. An oil-slick was formed completely around the boat, and she rode easily and in perfect safety over the tremendous swell which took the place of the previously breaking seas. The effect was such that little if any water came over the side of the boat, and the occupants were even able to lie down and sleep; and all this in spite of the fact that the boat was very deeply laden. Two of the boats eventually reached the islands, landing at different islands at first but later coming together. The 'Slivemore' was commanded by Captain Conby, and but for his forethought every soul among the crew and passengers would have surely lost their lives."

From the Northwest.—We can commend Lake Pend d'Oreille to those who are fond of quiet beauty, almost entirely unchanged by the hand of man. The writer saw it in the holiday season. Everything about it was then fresh and green and it seemed to him the most beautiful sheet of water he had ever seen. The writer of the following, from the *Northwest Magazine*, is evidently familiar with it and we will let him tell of it in his own words:

"The narrow northern end of Idaho, that is thrust up between

Montana and Washington and is seeking political union with the latter territory, contains a mountain lake of rare beauty. Lake Pend d'Oreille, named by the early French voyageurs from its resemblance in shape to the pendant ear-rings worn at the time it was discovered, is not surpassed for wild natural beauty by any lake on the American continent, and invites comparison of its natural features with such famous European lakes as Luzerne, Zurich, Como and Maggiore. The Cabinet Mountains border its eastern shore and from its southern and western shores rise in sheer precipices and steep, snow-flecked slopes the giants of the Bitter Root and Cœur d'Alene ranges. The highest peaks of these ranges have an altitude of over 10,000 feet. The immediate shores of the lake are covered with an open growth of evergreen trees, and the ground is thickly carpeted with grass and flowers. Many swift trout streams run into it. Its chief inflowing river, as well as its outlet, is the Clark's Fork of the Columbia. On sunny days the waters of the lake are of many hues of an indescribably beautiful green color. Its greatest length is about thirty miles and its average breadth ten.

"Hitherto this charming lake has seldom been visited by tourists and has been seen only from the car windows and platforms of passing trains. There have been no accommodations for visitors, the only habitations on the shores being the huts of timber cutters and the tepees of the harmless Kootenai Indians, except at the little village of Sand Point, where there are a few traders' stores. A pretty little hotel for summer visitors has just been completed at Hope, on the eastern shore of the lake and convenient to a station on the Northern Pacific Railroad, and trans-continental travellers can now break their journey at a place which combines more beauties of lake and mountain scenery than can be found elsewhere this side of Switzerland. Lake Pend d'Oreille has peculiar advantages for a summer resort, besides its sublime scenic features. Its remoteness from civilization is a special charm. Then there is excellent fishing; deer, elk and mountain lions can be shot in the woods; sandy beaches invite to bathing and shady, grassy banks to camping; for sailing and rowing the lovely lake stretches out its arms into

many a sheltered cove and bay and around many verdant islands; the elevation is about 3,000 feet above the sea level, which ensures cool nights; the mountains tempt the hardy climber, who knows the incomparable exhilaration felt by those who mount to lofty summits, over rock and snow, and look off on illimitable horizons. In time this distant and lovely Idaho lake must become known to thousands of lovers of nature. It is well worth going even further than two-thirds of the way across the continent to see."

* * *

A Dakota writer thinks that tornadoes are neither new nor increasing in number. The first one recorded is described as follows: "There came a great wind from the wilderness, and smote the four corners of the house, and it fell upon the young men, and they are dead."

He goes on to say that "the blizzard belongs to the great northwestern prairies, and is unknown east of the Big Woods of Minnesota. There never has been a blizzard in the vicinity of St. Paul. Leave the blizzard also in its proper home. Even there blizzards are not very common. There has been no real blizzard in Minnesota or Dakota for several winters past. When," he says, "the great prairies of Dakota are all under cultivation, and belts of timber surround every farm, and trees border all the roads, blizzards will be unknown."

* * *

There are numerous signs that the immigration into the Northwest is rapidly growing and will soon become very large. The magazine above referred to says that the number of letters being received at the Northern Pacific land office in Portland from intending immigrants is reported very large—more than three times greater than ever before. They come from every State in the Union, and from Denmark, Sweden, Norway, and of late, many from Germany. The talk of war there is evidently causing many to wish to depart to some place where the revengeful Frenchman is not likely to come prancing around seeking whom he may devour. The company's agent is kept busy day and night addressing information to the different anxious

inquirers in a dozen different languages. The largest immigration ever known is to be expected in the New Northwest this year.

The Northern Pacific railroad will soon be completed to Tacoma. It has not up to this time owned a line through to the Pacific, its line to the Columbia river having been pieced out to Portland by the line of the Oregon Railway and Navigation Company along that river. The line owned by the Northern Pacific, and now nearly completed, crosses the Columbia and, leaving it, traverses Washington territory, crossing the Cascade Mountains at a considerable elevation at Stampede pass.

THE NEVADA WEATHER SERVICE.—The following act, passed by the last legislature of Nevada, may be of service as a guide in drawing up similar bills in other states. Mr. Charles W. Friend will probably be, if not already, appointed director of the service. It is a highly proper appointment.

AN ACT to establish a Weather Service Station in Nevada and to provide for the appointment of a Director thereof, and appropriating money to pay the expenses of the same.

The People of the State of Nevada, represented in Senate and Assembly, do enact as follows:

SECTION 1. The establishment of a weather service station being necessary to secure as complete a history of the weather of Nevada as possible, in order to furnish trustworthy material for a study of its climate, to acquaint the people of the State and non-residents with the physical conditions of every locality, based upon reliable climatic data, thereby greatly benefiting the agricultural, commercial, manufacturing and municipal interests there is hereby established at Carson City, in this State, a central weather station, to be under the supervision of a competent director, to be appointed as hereinafter provided.

SEC. 2. The duties of said Director shall be to establish volunteer weather stations throughout the State, at least one in each county, and to supervise the same; to receive reports from said volunteer weather stations; reduce the same to tabular form, and prepare and have printed monthly reports, copies of which shall be, by said Director, sent to all colleges, high schools, hos-

pitals, public libraries, agricultural societies and newspaper proprietors, who shall in writing request the same.

SEC. 3. Said Director shall also prepare an annual report of his labors, and of the work done by the volunteer weather service, and present the same to the Governor for publication. Fifteen hundred copies of said report shall be printed by the Superintendent of State Printing, of which five hundred shall be for the use of the State officers, and one thousand shall be for the use of the Legislature. The Superintendent of State Printing shall do all printing necessary to carry out the requirements of this Act, and the Secretary of State is authorized to furnish to said Director whatever stationary he may need in the proper performance of his duty.

SEC. 4. Said Director shall be appointed by the Governor, and in addition to the other duties required under the provisions of this Act, he shall file with the State Librarian monthly reports of the meteorological observations provided for in the third section of this Act, and the same shall be carefully preserved by said Librarian and be open to inspection during office hours to anyone applying therefor. For the performance of the duties prescribed by this Act the Director hereinbefore mentioned shall receive a salary of six hundred dollars a year, payable in monthly installments, upon the claims being allowed by the Board of Examiners, and said claims shall be paid as other claims against the State are paid, and shall be in full of all demands of said Director, including traveling expenses.

SEC. 5. Said Director is authorized to provide for the equipment of such volunteer weather stations as shall be established by him, of which there shall be at least one in each county, at a cost not exceeding twenty-five dollars for each station so established. Each station shall be supplied with the following instruments: One maximum thermometer, one minimum thermometer, one dry bulb thermometer, one wet bulb thermometer, one rain gauge, with overflow attachment, and such other instruments as may be necessary, of which the cost shall not exceed the sum of twenty-five dollars for each station, as hereinbefore provided. Said Director shall apply to the United States Cen-

tral Signal Office in Washington, D. C., to have the weather stations in this State recognized and registered as volunteer stations, auxiliary to the United States weather service, and shall also apply for and receive the printed blanks, franked envelopes and books of "instructions for voluntary observers of the Signal Service of the United States Army," and such other stationery as is usually supplied to volunteer observers. All instruments purchased with State funds by said Director for use in any department of the weather service in this State, and all charts, maps, diagrams and tabulated forms made by him in his official capacity, shall be the property of the State solely.

SEC. 6. For the purpose of paying the salary of the Director herein mentioned during the years 1887 and 1888, the sum of twelve hundred dollars is hereby appropriated out of any moneys in the General Fund not otherwise appropriated.

SEC. 7. The sum of five hundred dollars is hereby appropriated out of any moneys in the State Treasury not otherwise appropriated, to be applied in purchasing the instruments provided for in the fifth section of this Act.

SEC. 8. The County Auditors of the respective counties of this State are hereby constituted Volunteer Reporters of meteorological observations and shall keep and record such observations and reports as are required by the provisions of this Act, and report the same to the Director of the Nevada Weather Service, and perform such duty without compensation additional to that now allowed by law for the performance of other duties of their office.

WINTER THUNDER-STORMS.—From the *Monthly Weather Review* it appears that there was an unusual number of thunderstorms during February, 1887. They are not uncommon in the Southern States at this season, but this year they were also common in the Northern States, especially so from Iowa to Ohio. They occurred on several dates, but were most frequent on the 17th and 18th, when they also covered New York and New England.

These electrical disturbances accompanied a well marked

storm-area which was traced continuously by the Signal Service from the Pacific, off Cape Mendocino on the 14th, to near the west coast of Ireland, on the 23d. After its discovery, it "moved southward along the coast line, after which it passed over southern California to Nevada during the 15th. It became well defined as an area of low pressure while on the Pacific coast, and the location of the centre of disturbance has been given for each telegraphic report from the time of its first appearance until it finally disappeared over the Gulf of Saint Lawrence; it crossed the Rocky Mountains near the fortieth parallel and was apparently retarded in its movements until it reached the Missouri Valley, after which the easterly movement was more rapid. The average velocity during its entire course, while under observation, was twenty-eight miles per hour. The barometric pressure was unusually low at the centre while passing over the eastern Rocky Mountain slope, and it was below 29.00 in the lower Missouri Valley; the depression was almost circular in form, and when in the central Mississippi Valley was bounded by eight continued isobars, ranging from 29.1 to 29.7. After moving over the Lake region the pressure increased slightly at the centre of the storm, which evidently reached its maximum energy while crossing the upper Mississippi Valley. The rain-area attending this disturbance included all sections of the United States, except the lower Rio Grande Valley. although the precipitation was not unusually heavy, except on the southern Pacific coast." After crossing Canada it passed over the northern end of Newfoundland, on the 20th. It seemed to increase in energy as it advanced across the Atlantic, where it was reported as accompanied by hurricane winds, high seas, and heavy rain.

During the thunder-storms accompanying this centre frequent readings of the electrometer were made at New Haven. The observations are given in the *Review*, with the following remarks which will be of interest: "An investigation of this table will show that this winter thunder-storm presented, as regards the electrical conditions, the same general features as the storms of the previous summer. Among many other points, we may

notice briefly the rapidly fluctuating character of the curve; the disturbances in the potential, due to the inductive action of the clouds, the values increasing with the cloud's approach and decreasing with its passage; the character of these fluctuations, compared with those due to other causes, being marked by a steadiness of movement in one or the other direction; the rapid changes in value, immediately after or simultaneous with, flashes of lightning; and, finally, the fluctuations due to rain drops. With regard to the lightning, it would seem that certain discharges occur, which, while not seen, are indicated by the electrometer. For a short time immediately preceding a flash of lightning there occurs a quick, steady rise in the potential, until the electrical tension becomes so great that a disruptive discharge occurs. (It might, incidentally, be remarked that, according to Thomson, air at ordinary pressure and temperature can support an electric tension of 9,600 grains weight per square foot before a spark passes.) With the passage of the spark the electric tension ceases and equilibrium is restored. With every flash of lightning the potential immediately falls to zero, to begin slowly to increase, then more rapidly, until the disruptive discharge again occurs. From all this it must be seen that in the electrometer we have but the first application of certain principles in electricity, which can be made of practical service in warning us of the probability of lightning strokes, as well as the advent of the storm."

ROYAL METEOROLOGICAL SOCIETY.—The usual monthly meeting of this Society was held on Wednesday evening, the 30th of April, at the Institution of Civil Engineers, 25 Great George street; Mr. W. Ellis, F. R. A. S., President, in the chair.

Mr. Robert Barnes, M. D., F. R. C. P., and Mr. L. L. Latrobe-Bateman were balloted for and duly elected Fellows of the Society.

The following papers were read:

(1) "The Storm and Low Barometer of December 8th and 9th, 1886," by Mr. C. Harding, F. R. Met. Soc. This gale will long be remembered as the one in which twenty-one lives were

lost in the life-boat disaster off Formby through the capsizing of the Southport and St. Anne's life-boats. The violence of the storm was felt over the whole of the British Islands as well as over a great part of the continent of Europe, the force of a gale blowing simultaneously from Norway to Spain. The strongest force of the gale in the United Kingdom was experienced in the west and southwest, and the highest wind force recorded by any anemometer over the country was a velocity of eighty miles in the hour registered at Fleetwood, whilst at Valencia, Scilly, and Holyhead the velocity reached seventy miles in the hour. The most exceptional feature of the storm was the extraordinary low reading of the barometer and the long time that the mercury remained at a low level. The absolutely lowest authentic reading was 27.33 ins., at Belfast, and the barometer fell below 28 inches over a great part of England, Scotland, and Ireland. At Aberdeen the mercury was below 28 ins. for eighteen consecutive hours, and below 29 ins. for more than sixty hours, whilst in the north of England the barometer readings were equally exceptional.

(2) "Report of the Wind Force Committee," drawn up by Mr. G. Chatterton, M. A., F. R. Met. Soc. In this report, which is a preliminary one, the Committee have dealt mainly with that portion of the investigation relating to Beaufort's Scale of Wind Force and the equivalent velocity in miles per hour. The Committee have compared the velocities as recorded by the anemographs at Holyhead, Falmouth, and Yarmouth, with the entries of Beaufort's Scale in the logs of the neighboring lightships and lighthouses for the year 1881, and they gave the results in a table. After a careful consideration of the whole of the results of this investigation, the Committee are of opinion that the velocities shown by the Yarmouth anemograph, corresponding to Beaufort's Scale as recorded on board the lightships, are too high, and that the velocities shown by the Falmouth anemograph are probably too low. The Committee, however, have not yet had before them sufficient data to determine with any degree of certainty the relation between Beaufort's Scale of wind force and the equivalent velocity in miles per hour. Neither are they

able to recommend any existing scale that can be adopted or modified.

(3) "A new form of Velocity Anemometer," by Mr. W. H. Dines, B. A., F. R. Met. Soc. In this instrument an attempt has been made to measure the velocity of the wind by the rotation of a small pair of windmill sails, the pitch of the sails being altered automatically, so that the rate may always bear the same ratio to that of the wind. The mechanical details are briefly as follows: A helicoid is fixed at the front, and a small pair of sails of variable pitch at the back of a steel rod, and just behind the helicoid a light fan, which can turn on the same axis, but is independent of the helicoid and sails. If the rotation be too rapid, the fan turns in the same direction as the helicoid, and by its motion alters the pitch of the sails so that their motion is retarded; if, on the other hand, the friction is increased, or from any other cause the motion becomes too slow, the fan is turned in the other direction, and the rate is increased. The motion is communicated to a vertical rod, which passes down the hollow pivot on which the instrument turns: it is kept facing the wind by a vane. It is convenient to connect the vertical shaft to the recording dial by a light flexible wire, all that is necessary being to place the dial approximately beneath the anemometer; by this mean the trouble of ascending a high tower or ladder is avoided, except where oil is required.

(4) "Description of two New Maximum Pressure Registering Anemometers," by Mr. G. M. Whipple, B. Sc., F. R. Met. Soc. The simplest instrument is a modification of the Lind's, Hagemann's, or Pitot's water pressure anemometers, provided with an apparatus for registering the maximum height the water attained during the period which elapsed since the last setting of the instrument. The second form of registering maximum pressure anemometer is derived from the ordinary pressure plate instrument; a circular metallic disc of $9\frac{5}{8}$ ins. diameter exposing a surface of half a square foot is kept at right angles to the wind by means of a suitable vane. This disc is perforated by eight circular apertures each of $1\frac{3}{8}$ inch in diameter. Behind each aperture a disc $1\frac{3}{4}$ inch in diameter is loosely held *in situ*

by means of a bent lever loaded with a weight. These weights are arranged so as to press upon the different discs with pressures proportionate to the values usually assigned to wind pressures measured by the various degrees of the Beaufort scale.

SOME RESULTS OF THE WIND OBSERVATIONS MADE IN 1886 AT THE BLUE HILL METEOROLOGICAL OBSERVATORY.*

Great Blue Hill, ten miles south of Boston State House and 635 feet above sea level, is the highest land within ten miles of the Atlantic coast from Maine to Florida. Blue Hill is a good place to study the winds on account of its free exposure, being uninfluenced by the natural or artificial irregularities of surface which affect the records of most of our Signal Stations. Though distinctly in the lower circulation of the air, unlike the high stations on Mt. Washington and Pike's Peak, it is remarkable for its uniformly high wind velocity, the records for the year 1886 showing it to rank third in the list of stations reporting the most wind to the Signal Service. In round numbers representing miles the total annual wind movement for these stations was: Mt. Washington, N. H., 276,000; Pike's Peak, Col., 184,000; Blue Hill, Mass., 165,000; Cape Mendocino, Cal., 163,000; Sandy Hook, N. J., 141,000. It should be remarked that these numbers are not proportional to the height of the stations, Mt. Washington having much more wind than Pike's Peak, which is more than twice as high. The average wind velocity on Blue Hill was 62 per cent. greater than on the roof of the post office building in Boston, some 170 feet above the street, the rates in miles per hour being 19.0 to 11.7.

The instruments in use at Blue Hill for recording the direction and velocity of the wind are the anemoscope and anemometer of Dr. Draper, (of which a description will be found in the JOURNAL for April, 1885), an anemometer of the Signal Service pattern, registering electrically, and a pressure gauge constructed by the writer. The latter presents a disk with a

*Read before the New England Meteorological Society, April 19th, 1887, by A. Lawrence Rotch.

square foot of surface normal to the wind by means of a vane. Pressure of the wind upon the disk stretches a spring and leaves an index at the maximum pressure in pounds to which it has been subjected in the course of the day. The agreement of this gauge with the anemometer, after the equivalent velocity is deducted from the pressure, is remarkable, as the following table shows. The velocity corresponding to the recorded pressure is obtained from the table computed by Colonel James who assumed that the square of the velocity in miles per hour, multiplied by 0.005, gave the pressure in pounds per square foot. The Blue Hill experiments seem to show that this formula gives a close approximation to the relation between pressure and velocity. The extreme velocity of the gusts would naturally be expected to exceed the mean velocity for five minutes as shown by the anemometer, and this is generally found to be the case.

Relation of the Pressure to the Velocity of the Wind.

Max. Pressure in lbs. per square foot.	Equivalent Velocity in miles per hour.	Highest Mean Velocity for Five Minutes in miles per hour.	Number of Experiments Quoted.
2.0	20	22	3
4.0	28	28	3
6.0	35	35	3
8.0	40	38	3
10.0	45	40	2
12.0	49	45	3
15.0	55	55	2
17.0	58	56	3
21.5	66	65	1
24.0	69	64	1
25.5	71	66	1
26.0	72	70	1
26.5	73	66	1
31.0	79	75	1
32.5	81	72	1
36.5	85	84	1
43.7	93	84	1

It will be noticed that the agreement is closest generally at moderate velocities, but whether this is due to the inertia of the pressure plate causing it to lag with light winds, or whether the velocity of the gust exceeds in a greater ratio the mean velocity during high winds than during low ones, cannot be stated.

By means of the anemoscope and anemometer hourly values of the direction and velocity of the wind have been obtained for 1886 and reduced for publication. So far as known to the writer

this will be the only data for hourly wind velocities published in this country.

The table of wind direction shows the following frequency of the different winds during the year, in hours:

S. E.	S.	S. W.	W.	N. W.	N.	N. E.	E.	Calm.
620	1102	1422	1603	1458	892	1005	632	2

The few calms will be noted, but reference to the records of the sensitive Signal Service anemometer shows that there were no actual calms of an hour's duration during the year. During the winter months the winds are mostly from the northwest, and during the summer months from the southwest. Regarding the months collectively there seems to be a tendency of the wind to veer (*i. e.*, rotate with the sun) from west in January to west again in December, but this could only be established by the mean of several years' observations. It may be noted that a contrary, or retrograde, motion has been found to prevail at a number of stations in Europe and Asia. (See *Das Wetter*, Feb., 1887.)

The annual means of the hourly wind velocities give the following, in miles per hour:

A. M.

12–1	1–2	2–3	3–4	4–5	5–6	6–7	7–8	8–9	9–10	10–11	11–12
19.2	19.1	19.0	19.0	18.9	18.8	18.5	18.1	18.3	18.6	18.7	19.0

P. M.

12–1	1–2	2–3	3–4	4–5	5–6	6–7	7–8	8–9	9–10	10–11	11–12
19.5	19.6	19.7	19.9	19.4	19.3	19.0	19.3	19.2	19.1	18.7	18.5

MEAN.

19.0

The chief maximum (19.9) is seen to occur between 3 and 4 P. M. and the chief minimum (18.1) between 7 and 8 A. M. This agrees substantially with observations made at low level stations elsewhere though the diurnal variation (1.8 miles per hour) is less, probably, on Blue Hill than at lower stations. Thus Loomis states that at Philadelphia the mean force of the wind is least about sunrise and greatest about 2 P. M., the pressure at noon being fully double that at midnight. Observations made at Greenwich, England, during 1884, show the maximum ve-

locity to occur at 3 P. M., and the minimum at 5 A. M., the difference between the maximum and minimum velocities being 4.6 miles per hour.

Referring again to the Blue Hill observations, certain months show abnormal times for the occurrence of the maximum and minimum velocities, viz., January with its maximum of 23.0 miles between 4 and 5 A. M., and the minimum of 18.9 miles between 4 and 5 P. M.; and June with its maximum of 17.3 miles between 1 and 2 A. M., and its minimum of 12.8 miles also in the morning between 7 and 8 o'clock. The first-named month is the only one showing a complete inversion of the wind's diurnal period, *i. e.*, with the maximum velocity during the night and the minimum during the day as has been found to be the case throughout the year at high mountain stations, such as Mt. Washington in this country, Ben Nevis in Scotland, and the Sentis in Switzerland. The writer, therefore, wishes to correct his assumption made in an article on "The Inversion of the Wind's Diurnal Period at Elevated Stations" in the JOURNAL for May, 1885, that the plane of the inversion of the wind's diurnal period may be at a lower altitude than Blue Hill, since, during the month of February, 1885, the increase there in the wind's velocity during the night hours was 0.9 mile per hour, while the Boston record showed an increased velocity during the day hours over the night hours of 0.4 mile per hour. This was evidently an abnormal case, for the phenomenon has not been repeated since, except in the month of January, 1886, previously mentioned. For this month the Signal Service observations at Boston, 500 feet lower than Blue Hill, at the hours of 3, 7 and 11 A. M. and 3, 7 and 11 P. M., show the maximum velocity of 13.3 miles per hour to have occurred at 3 P. M., and the minimum of 10.9 miles per hour at 11 P. M., that is, the inversion noted on Blue Hill was not exhibited at Boston. The hours of maximum and minimum velocity which were abnormal on Blue Hill during June, were, from the Signal Service data for Boston, 3 P. M. (12.3 miles) and 3 A. M. (9.0 miles), but the increased velocity here during the afternoon was evidently caused by a sea breeze, as shown by the direction. In both February, 1885, and January,

1886, the mean pressure was below the normal and each month was the coldest of its respective year, but to neither of these conditions can be ascribed the inversion of the wind's diurnal velocity on Blue Hill.

Periods of ten days in other months of 1886, during anticyclones, have, however, showed inversions which can more easily be explained. Some of these periods are as follows:

Feb. 1–10, max. 23.0, 3–4 A. M.; min. 17.1, 4–5 P. M.
July 1–10, max. 18.4, 1–2 A. M.; min. 11.4, 11–12 P. M.
Sept. 21–30, max. 18.3, 12–1 A. M.; min. 14.0, 2–3 P. M.

The inversion of velocity between day and night during such periods of high pressure and strong insolation, is very probably due to the sea breeze which during the middle of the day blows in from the east with moderate velocity and checks or reverses the prevailing west winds which, on account of the gradients favorable to them, resume their strength at night.

The cause of the inversion in the wind's diurnal velocity at high altitudes is stated by Dr. Köppen in the writer's article before mentioned. Prof. W. M. Davis has reviewed the subject in his second paper on "Mountain Meteorology" in *Appalachia* for Dec., 1886. It appears evident that the height of Blue Hill is not sufficient to show the inversion in the wind's diurnal velocity, except during certain peculiar conditions, which are not yet fully established.

OBSERVATIONS OF ATMOSPHERIC ELECTRICITY.

PART III.

A very elaborate discussion of some observations made at Kew, in 1845–46 and 1847, by W. A. Birt* gives the following among other deductions: "The daily march of the electrical tension has been found to present, two well defined maxima, in most instances removed from each other, by an interval of 12 hours, the principal maximum occurring at 10 P. M., the other at 10 A. M. Two minima have also been ascertained, the principal

*Report British Association, 1849, pps. 113, et seq.

at 4 A. M., the subordinate at 4 P. M. At a particular season of the year, there have been indications of a curve of low tension presenting considerable approximation to a single progression, more or less in harmony with the curve of temperature." Of 10,256 observations, 10,176 were recorded as positive. Ten of the observations at which negative electricity was recorded, were not accompanied by rain. One interesting case is noted where the same character of disturbance was recorded synchronously at Kew and Greenwich, although at the former place occurred showers and hail, while the latter place was without rain.

Of the observations made at Gaud, described by Duprez,* from 1855 to 1864, the following table gives the chief results. The electrometer used was one of the Peltier form, and the values given are degrees of deflection of the needle, and the equivalent proportional numbers.

	1855.	1856.	1857.	1858.	1859.	1860.	1861.	1862.	1863.	1864.	Mean.
January	32	20	19	22	12	19	18	13	9	14	18
February	32	14	18	17	12	17	4	9	8	11	14
March	17	7	10	10	7	10	4	4	5	8	8
April	12	7	5	6	7	5	2	3	4	5	6
May	5	6	2	4	2	3	3	2	3	3	3
June	6	6	6	4	4	3	4	1	2	1	4
July	7	8	6	5	2	4	4	2	1	1	4
August	5	7	4	8	4	4	5	1	3	2	4
September	5	8	10	10	7	4	4	3	6	3	6
October	10	17	19	12	13	11	7	5	8	6	11
November	22	23	22	28	20	11	13	6	13	10	17
December	24	22	22	18	20	9	13	10	12	10	15
Mean	15	12	12	12	8	8	7	5	6	6	9
Mean. Prop. numbers	60	36	31	27	17	17	15	7	9	9	23

The means of the proportional numbers for the four seasons of the year, are; winter (Dec., Jan. and Feb.) 43; spring (March, April and May) 11; summer (June, July and Aug.) 11; and autumn (Sept. Oct. Nov.), 27.

There are of course, in all these measurements, where a small magnet is used to give the directive force, periodic errors, from the changes in the intensity of the horizontal component of the

*Bull. d. l'Acad. r. d. Belgique 2nd series, Vol. XXVI, pp. 144, Vol. XXXI, pp. 202.

earth's magnetism; and in the determination of the secular periodicity of atmospheric electricity, this must be carefully distinguished.

Eliminating all dates of storms, local disturbances, etc., the means reduce to, for winter 38, for spring 8; for summer 4, and for autumn 20.

From what precedes, it appears, first, that at Gaud, as elsewhere, the monthly mean is greatest in January, and least in May.

With regard to the influence of cloudiness, the following table is given, in which 10, expresses a sky entirely covered with clouds.

	10. Sky entirely covered.	9.8.7.	6.5.4.3.	2-1-0.
January	31	28	40	60
February	17	38	39	43
March	9	13	15	23
April	8	8	11	12
May	6	4	8	5
June	5	4	5	6
July	8	5	4	8
August	4	5	6	7
September	8	8	8	13
October	18	26	15	29
November	26	27	34	43
December	29	30	36	37
Mean	14	16	18	24

In winter, then, the less the cloudiness, the higher as a rule, the electrical potential, but this does not hold for summer. The proportional numbers for skies, entirely clear, and entirely clouded, show that the electricity for both summer and winter for a sky perfectly clear is twice that for a cloudy sky. The electricity during storms without rain, hail or snow, has been constantly positive.

Between spring and summer, at Gaud, is the time when the negative electricity is not only most frequent but of the highest potential, and on the other hand least frequent and of smallest value in winter. With regard to the influence of wind direction and also atmospheric pressure, Duprez thinks, that westerly winds show a greater electrification than easterly and that negative electricity in general occurs with lower pressures than the

positive. The observations at Gaud, as well as Brussels, show that the electricity of the air, negative as well as positive, increases with rain-fall or other precipitation. Observations at these two places, also seem to show a slight influence under ordinary conditions, exerted by the wind direction, and by the pressure, upon the electrical potential. But in the case of negative electricity this relation does not seem to hold.

The observations next requiring our attention are those made by Palmieri, at Vesuvius and elsewhere. These observations were begun in 1850 and have been continued until the present date. The instruments employed and the methods adopted by Palmieri differ from those hitherto mentioned and will be described later. The results* in general deduced from his observations are:

(1) Negative values observed during clear weather, are always an indication of rain-fall, or snow or hail, at some distance from the place of observation, not greatly exceeding 50 or 60 kilometers.

(2) It is only during precipitation or just in advance, that we have the high potentials and sparks.

(3) These high potentials are closely connected with the rain, and clouds are to be considered as charged conductors suspended in the air, and which suddenly condensing free large quantities of electricity. Disruptive discharges take place when the dissipation through silent agencies is not sufficiently rapid.

(4) During cloudy weather, not accompanied with rain within a distance of from 60 to 70 kilometers, the electricity is always positive but feebler than under a clear sky.

(5) If during cloudy weather negative indications are noticed, it is a sign that rain is falling at a distance.

(6) Atmospheric electricity is produced by the condensation of vapor, consequently an increase of the electricity always follows an increase in the relative humidity of the upper layers of the air.

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* "Deux. Congres. Intern'l. des Meteor." Rome, 1879, p. 261, et seq.; also, "Legge ed origine della elettricità atmospherica," 1882, and "Die Atmos. Electricität," by H. Discher, 1884.

(7) A strong development of positive electricity takes place where the rain is falling, and surrounding this is a zone of negative electricity, around which in turn is another zone of positive electricity. Somewhere of course between the two zones the potential is zero. If with the cessation of the rain, the negative values still prevail, it simply shows that some distant rain, exerts a influence sufficient to mask that existing at the place.

(8) The laws stated above, hold for all storms with or without hail. Sometimes it may happen during a storm that the thunder clap is immediately followed by a change of sign, because the different zones, mentioned above have amplitudes depending on the quantity of vapor converted to rain, the rapidity of condensation, and in part on the humidity of the air between the clouds. At each flash of lightning, the registering electrometers give for an instant, an opposite sign to that of the prevailing electricity, and so we have sometimes a feeble diminution and at other times a very great increase.

If a cloud, from which rain is falling is really a source of electricity, it is evident that during the fall of rain it will be easy to note an endless number of discharges from a single cloud, without a complete discharge, and which shall cease when the rain ends.

(9) The development of electricity depends upon the quantity of rain, and the rapidity of its formation. If the electricity is dissipated silently we have rain without lightning, but it is not possible to have lightning without rain, excepting perhaps the case of the matter ejected during a volcanic eruption when a large quantity of ashes and cinders are thrown into the air. Lightning is never without thunder, and the two are always accompanied by precipitation. Lightning without thunder, is simply the lightning of a distant storm, as I have time and time again ascertained by means of the telegraph. The longest interval I have noticed, between the flash and the thunder, is about 59 seconds, equivalent to a distance of 20 kilometers. During the night, lightning can be seen at a much greater distance than this.

(10) During calm and quiet days, the diurnal curve seems to

show two maxima, one in the morning, becoming later as the elevation of the place of observation increases. At Naples, it occurs about 9 to 10 A. M., at Vesuvius about 2:30 P. M. The maximum of the evening on the other hand, is earlier in general, the more elevated the station, but is less distinctly marked at high, than at low elevations.

(11) When the sky is clear, and there is no wind, any marked fluctuation in the daily curve, and the appearance of abnormal maxima at unusual times, denote the approach of a storm, and in all probability heavy rain.

(12) It is the common belief that atmospheric electricity increases with elevation, but this assertion is not generally true, excepting for small difference on a general level. The mean of a number of observations made simultaneously by myself at sea-level near Naples, and by Professor Semmola at the University Observatory, shows a rather feebler potential at the higher station than at the lower, the difference in elevation being some 57 meters. The synchronous observations made at Naples, the Capidomonte University and at Vesuvius, the synchronism being assured by the aid of the telegraph; and also the observations at Moncalieri, and the lower St. Bernard, show that the electricity diminishes with an increase in elevation. If Vesuvius is tranquil, it is very seldom the case that the electric potential at the observatory there is greater than that observed at Naples.

(13) The annual period shows a minimum in summer, but since a warmed air, for any given decrease in temperature under the same conditions of saturation will precipitate a greater quantity of moisture than a cold air, it should follow that—the fluctuations characteristic of stormy weather, should be more frequent in the summer months.

The views of Palmieri, as given above, it should be mentioned are not in the main assented to, by other observers; and on some particular questions, these views would appear to be in direct opposition to the experiments of others.

The next of the more important observations at Paris, are those made at different times by Mascart, and under his direction. A self-registering instrument was in use for some time, and a contin-

uous record obtained. A modified form of the Thomson Quadrant electrometer was employed. The deviations of the needle are transmitted every two and a half minutes, by a pencil to paper, giving in this way, not a continuous curve but a series of points through which a close approach to the curve may be drawn. The apparatus * was put into operation at the "College de France" in February, 1879, and curves have been obtained since that date without serious interruption, and can now be discussed. The most apparent deductions are these:

In general the potential of the air is positive, with more or less rapid variations. During cloudy weather the curves are more irregular and rain is almost always accompanied with large negative values. The change in character occurs previous to the advent of the rain, and sometimes the rain is followed immediately by high positive indications. There are also a few cases where with rain, the indications are positive, and on the other hand no rain with large negative values. The predominance of negative electricity in rain clouds appears to Mascart to be an important consideration in the discussion of the origin of atmospheric electricity.

Neglecting accidental variations, and examining the curves generally, it will appear that the curve is more uniform during the night and more variable during the day. The potential is noticeably higher during the night than during the day. The maximum appears to occur about 9 or 10 P. M., the curve descending gently until about 6 A. M.; then more rapidly until it attains a minimum about 3 P. M., when it again rises at a uniform rate.

With regard to the monthly values, the following table gives the means for eight tri-hourly observations. In this table, all observations made during rain, and other disturbances, and all negative indications. The scale is an arbitrary one.

	Midnight.	3 A. M.	6 A. M.	9 A. M.	M.	3 P. M	6 P. M.	9 P. M.
March.....	24.7	19.2	19.1	13.6	14.5	14.9	21.2	27.1
April	24.0	23.7	24.0	16.0	17.0	13.3	28.5	26.0
May.....	24.5	23.3	26.0	20.7	13.8	15.5	15.4	24.5
June	26.7	25.5	25.4	17.6	14.6	12.0	18.4	25.0
July	33.3	34.5	33.7	28.8	26.7	23.6	29.3	36.1
Mean.....	26.6	25.2	25.6	19.3	17.3	15.8	20.5	27.7
Total Mean of all observations...	26.6	25.2	24.6	15.8	12.7	9.8	13.2	26.9

*Ann. de la Soc. Meteor. XXVIII, 1880, pps. 8–12.

Naturally the variations are more regular in the mean of five months than in the mean of any one. In the total mean, account has been taken of the negative values, exceping only those occurring in connection with rainfall which evidently would be out of place. But even this total mean makes the minimum about 3 P. M. and the maximum about 9 P. M., or more properly, continuing on during the night. These results are in opposition to those generally given. Mascart remarks that the continued high positive be found to prevail during the night was perhaps, exceptional, and due to the anomalous conditions of the season. The observations* made in the following year, 1879-'80 confirm the results stated above. Rains with positive values are extremely rare and are never seen except during general storms. The approach of a storm is told by large negative deflections, followed by extended oscillations on both sides with a marked predominance of negative potential. The apparatus, it is true, is in the heart of a great city, and one might suspect that different results would be obtained in the country, but, nevertheless, many experiments bear me out in the assertion that, except at times of great perturbation, the seat of the disturbance is at a great distance from the ground; so that it is probable that influence of the city will not masque the diurnal variation. In the mean, the potential of the air, always positive, is higher and more uniform during the night than during the day. From 9 P. M. until 3 A. M. it varies but little, falling during the day and reaching a minimum about 3 P. M., after which it rapidly rises and reaches a maximum about 3 P. M., after which it "falls slowly to rise again to" a maximum about 9 P. M. There is then, but one minimum during the day and an almost steady maximum during the greater part of the night, that is to say, only one diurnal period, if we use the term in its strict sense. The amplitude of the daily oscillation was found to be noticeably small during the winter. In Mascart's opinion there exists some intimate relation between the electrical condition of the air, and the temperature, but requiring a more extended set of observations than were available for his discussion.

* "Sur l' électricité atmosphérique. C. R. XCI, 1880, pp. 158-161.

A discussion of some later observations*, in which continuous records were obtained by means of photography, seems to confirm his previous experience, particularly with respect to the maximum during the night.

The next observations which should be noted are those instituted in this country by the U. S. Signal Service. Beginning in 1883, observations were made at Cambridge, Mass., under the direction of Professor Trowbridge, and at Baltimore, Md., under the direction of Professor Rowland. Two years later ob-observations were begun and have been continued up to date at six stations, mostly on the Atlantic sea board. These observations are yet hardly in a condition to justify further discussion than that given from month to month in the *Monthly Weather Review.* Preliminary reports have been given of the observations at Baltimore† and those of Cambridge‡ and a much more complete and general resume of the results of the six stations and the plan and scope of the work contemplated by the Signal Office by Professor T. C. Mendenhall.§

An important set of observations, made very recently, is that of Müller and Leyst in Russia. A Carpentier form of Mascart electrometer and collecting apparatus similar to that employed by Mascart is used. A description of the exposure and apparatus will be given elsewhere in this paper. The following tables are the results obtained, the values given being in volts obtained by reference to a standard cell.

MEAN VALUES FOR BI-HOURLY OBSERVATIONS—PAWLOWSK, 1884.

	A. M.			P. M.					
Date.	6.48	8.48	10.48	12.48	2.48	4.48	6.48	8.48	10.48
May	150 volts.	139	126	124	118	131	130	131	142
June	134	135	116	107	113	127	128	124	132
July	152	138	130	140	118	135	143	148	149
August	268	236	182	187	207	217	242	277	298
September	224	232	198	183	182	209	243	257	265
October	235	238	226	194	192	233	239	243	.....
November	185	201	215	209	192	234	245	238	.....
December	239	336	288	266	336	204	192	232	.....
Mean	193	188	170	163	160	184	196	203	(197)

* "Sur les enregisteurs de l' électricté, etc." *Jour. de Physique*, t x, 1881.
† Signal Service Note, No. XVII, by Parke Morrill, 1884.
‡ Proc. Am. Acad., June, 1885. McRae and McAdie.
§ Am. Ass'n for Adv. Science, Buffalo, 1885.
Annalen des Phys. Cent. Obs., Part I, 1884, Pawlowsk.

THE MAXIMUM VALUES FOR THE DIFFERENT MONTHS ARE:

1884	Maximum.	Minimum.	Exceeding 600 volts.	Less than 0
January	K*	−675	1 observation.	12 observations.
February	511	−675	no "	4 "
March	3276	−855	10 "	4 "
April	546	−2307	no "	5 "
May	649	−K	1 "	15 "
June	K	−K	1 "	6 "
July	K	−3254	1 "	7 "
August	769	−1485	3 "	5 "
September	4221	−1589	3 "	3 "
October	997	−931	1 "	5 "
November	1387	−1239	2 "	3 "
December	4212	−976	9 "	4 "

* K denotes deflections off the scale—*i. e.*, exceeding 3,000 volts.

THE MEAN VALUES FOR THE TRI-DAILY OBSERVATIONS WERE AS FOLLOWS:

	6.48 A. M.	12.47 P. M.	8.47 P. M.	Monthly Mean.
January	124	154	173	150
February	210	213	223	215
March	267	246	228	247
April	297	194	272	254
May	150	124	133	130
June	134	107	131	124
July	152	140	148	147
August	268	187	277	244
September	224	183	256	221
October	235	194	243	224
November	185	209	238	211
December	239	266	232	246

Some few observations of atmospheric electricity have been made in Madras, by C. Michie Smith.* The most interesting result would seem to be the establishment of the fact that in this locality negative electrification of the air, is not necessarily "associated with broken or stormy weather." The air has frequently been found to be so electrified during fine weather. Of the first series of observations made in 1883, there were twelve days between the 3d and 25th of September, on which negative readings were recorded. In March, 1884, there were negative readings on six days, with clear weather and south-westerly winds, no rain occurring until nearly a fortnight after the last negative reading; and from July 14th to 31st there were nega-

*Phil. Mag. Nov., 1885, pp. 456 *et seq.*

tive readings on seven days, on only one of which did rain fall at the place of observation, and then only a light rain some eight hours after. During August, negative readings occurred on nine days without any apprrent connection with storms. Some of these effects are doubtless to be explained by the action of dust in the air. And in general, it seems to hold true, that these negative indications occur at times when the air is dry and warm, and strong westerly winds are blowing. "Whenever the wind veered around so as to blow in the least degree from the sea, the potential at once became positive. This has been well marked in all cases, and when the sea breeze came on early in the day no negative readings were obtained, but when, as has happened on several occasions, the sea breeze was delayed till late in the afternoon, the negative readings continued until the wind veered around." The observations have not been extensive enough to permit giving a diurnal curve, but as a first approximation it would appear that a minimum is reached about 10 A. M., increasing steadily from then and reaching a maximum about 7 or 8 P. M. The observations made at Madras are of most interest, however, as bearing on the question whether electrification of the air is strongly influenced by dust in the air, especially when the air is dry and warm and the dust is in sufficient quantity, as would be the case in large cities and in the vicinity of sandy plains.

THUNDERSTORMS IN SOUTHERN RUSSIA.*

Prof. Klossovsky's report on thunder-storms in Russia, (summarized in this JOURNAL, May, 1886) has been followed by a second brochure giving a more detailed analysis of thunderstorms in southern Russia. The material for this study consists in the reports received during 1884 and 1885 from the district of Elisavetgrad, where eighty-two stations have furnished descriptions of more than 800 thunder-storms. The objects of the investigation are to find diurnal and seasonal period, and to discover laws of relation to areas of low pressure.

* Les orages au Sud de la Russie. Odessa, 1886, 41 pp.

The following table contains the percentage of storms beginning during each of the eight three-hour intervals of the day:

	A. M.	P. M.	P. M.	P. M.	P. M.	A. M.	A. M.	A. M.
Hours	9-12	12-3	3-6	6-9	9-12	12-3	3-6	6-9
Percentage of Observations.	9.9	29.6	32.7	15.3	7.2	1.7	0.6	3.0

from which it is seen that the periods of maximum and minimum frequency are respectively from 3–6 P. M. and 3–6 A. M.— The same is true of storms with hail, the observations showing that no hail was observed from 3–9 A. M. during the years of observation.

The monthly distribution is as follows:

	March.	April.	May.	June	July.	Aug.	Sept.
Percentage	1.2	8.3	27.4	35.0	23.5	2.5	2.1

Perhaps the most noticeable characteristic of this table as compared with American experience is the sudden diminution of thunder-storms in August, the month when in the United States thunder-storms are in some years the most frequent. This was the case for the past year, 1886, as shown by the number of storms reported in the *Monthly Weather Review* of the Signal Service for the successive months.

For 1884, of the years included in the Russian series, the monthly distribution in the United States is represented by the following relative numbers: May, 52; June, 97; July, 133; August, 79; September, 55; October, 16. The earlier epoch of maximum number of storms in southern Russia corresponds to the fact that June and July are the hottest months of the Russian summer.

The percentages of storms coming from the different parts of the horizon and the wind directions at the time of storms are as follows:

	N.	N.E.	E.	S E.	S.	S.W.	W.	N.W.	Calm.
Storm directions	8	7	14	14	19	16	14	8	
Wind directions	9	9	14	10	17	11	11	9	10

In the mean of a longer series the most frequent direction from which storms come in southern Russia is much more decidedly between the south and southwest than is presented in

this table. In *central* Russia the south and southwest winds present a more decided maximum frequency with thunder-storms than here exhibited for the southern districts.

With relation to the pressure prevailing during thunder-storms the observations at Elisabetgrad have furnished the following comparisons: Fifty-seven per cent. of the storms occur when the pressure is between 755 and 760 millimeters; that is, when the pressure is just below the normal. About equal frequency was exhibited with falling and with rising barometers; the ratio 1 to 1.11 in the two cases respectively is just about the ratio between the number of westerly and easterly winds accompanying the thunder-storms, namely, 206:232.

When an area of high pressure settles over Russia, there is an electrical calm, and likewise when an area of high pressure extends in a narrow belt northward and southward across western Europe, thunder-storm action is feeble or entirely ceases. Thunder-storms are attached to cyclones [areas of low pressure], but all cyclones do not bring thunder-storms. Electrical action is developed when the conditions of temperature and humidity (temperature high, relative humidity low) are favorable.

In July the storms had a more uniform distribution around the cyclone than in other months when they were very largely confined to the southeast quadrant. Similarly the thunder-storms of southern Russia have a more uniform distribution than in northern Russia where they are more restricted to the south and southeast portions of the cyclone.

The thunder-storms of southern Russia are connected with three principal systems of cyclones.

(1) Cyclones which first traverse northwestern Europe; (2) cyclones which come from central Europe; (3) low areas coming across the Black Sea.

For these three classes of cyclones the following data are presented:

Class.	Number of Cyclones.	Number of Thunder-storms.	Number of Thunder-storms to each cyclone.	Storms with hail.
(a). N. W	56	192	4	1.6
(b). Central	19	164	7	4.0
(c). Southern	23	168	9	2.0

Six thunder-storms occurred with uniformly distributed pressure and seventy-five were between two cyclones.

The cyclones coming from central and southern Europe carry, or develop, a greater quantity of electrical energy than the barometric depressions from northwestern Europe. The connection of hail with the cyclones of the central system is still more marked. The thunder-storm belt lies on the circumference of the cyclone between the isobars 750 and 760 mm., a region serving as a transition to areas of high pressure.

Klossovsky concludes that thunder-storms are small secondary whirls, formed on the borders of the principal cyclone, and especially in their southeast and southwest quadrants.

These whirls are of only small extent and therefore strike but a narrow belt of country. Sometimes several whirls, having a like point of departure, follow parallel paths or cross one another in their course; there results an obvious dissolution of the thunder-storms into several branches of storms. Finally, the sudden changes in the direction and force of the wind during the thunder-storm are only a natural consequence of the passage first of the anterior part, and second, of the posterior part of the whirl. A. M.

LOOMIS' "CONTRIBUTIONS TO METEOROLOGY."

THE DISTRIBUTION AND CAUSES OF RAIN.

The General Distribution and Causes of Rain.

"A comparison of the mean annual rainfall for different localities shows unequivocally the influences of general causes quite distinct from the peculiarities of particular storms. These general causes must operate upon each storm, and a distinct understanding of their nature must assist us in explaining the phenomena of particular storms."—Loomis' 16th paper.

In order to study the general distribution and causes of rain, Loomis collected and tabulated in his sixteenth and eighteenth papers all of the rainfall statistics available from every portion of the earth's surface.

The following were found to be places of excessive rainfall:

"1st. Stations on the north and east of the Bay of Bengal,

where the rain comes almost wholly with the southwest winds.

"2d. Stations on the west and south part of Hindostan and Ceylon (including a few interior stations), where the rain is also confined almost entirely to the southwest monsoon.

"3d. Islands situated within the tropics (including a few stations in China, Australia, and New Zealand) generally having mountains rising to a height of several thousand feet.

"4th. Stations on the east coast of the American continent chiefly within the limits of the trade winds, including a few stations somewhat distant from the coast.

"5th. Elevated stations in different parts of Europe, including the northwest part of England, the west of Scotland, the coast of Portugal, Norway, etc.

"6th. Stations on the west coast of Africa, including one in the interior.

"7th. Stations on the west coast of North America."

The following were found to be places of deficient rainfall: Ascension Island, Sahara, Southern California, South Africa, Australia, Tartary, Chili, Central Spain, the whole of the territory north of 60° N. lat. at a little distance from the ocean, and regions of great extent in the central parts of Asia and North America.

From a study of the conditions surrounding the places of excessive and deficient rainfall Loomis arrives at the general conclusion "that excessive rainfall results from an unusual strong and persistent upward movement of the atmosphere, while a deficient rainfall results mainly from an absence of this upward motion."* Seeking the causes more in detail, "the fol-

* The most honor for maintaining and establishing this principle belongs to Espy, who devoted almost his whole life to it. It is seen that every one of the more detailed causes of rain mentioned by Loomis are those which tend to give an upward motion to the air, viz.: the meeting of the trades, storms, mountains, etc. Espy showed that the reason why the ascent of air produces rain is because the air, which always contains vapor, becomes cooled by its own expansion in ascending and the cooling condenses the contained vapor into cloud and rain. The descent of air produces just the opposite effect. Of course the damper the air the less the amount of ascent necessary to produce rain; consequently, near large bodies of water, the slight ascent of air in passing over capes and headlands, or a gentle storm would produce rain; while in arid regions more decided storms, or very high mountains would be necessary.

lowing are believed to be the principal causes of excessive rainfall:

"1st. The meeting of the northeast and southeast trade winds resulting in a great rain-belt around the globe.

"2d. The irregular barometric depressions of the middle latitudes. The average track of great barometric depressions is not as distinctly marked by an excess of rainfall as might be expected; nevertheless storm tracks exhibit a tendency to incline towards districts where the rainfall is unusually great, *e. g.*, Newfoundland, Iceland, coast of Norway, North Italy, etc.

"3d. Mountain ranges causing increased rainfall on the side from which the prevalent wind proceeds.

"4th. Proximity to the ocean, especially when the prevalent wind comes from the ocean, *e. g.*, Western Europe, east coast of South America, Africa and Australia.

"5th. Capes and headlands projecting considerably into the ocean generally receive a greater rainfall than neighboring districts, *e. g.*, Cape Hatteras, Newfoundland, southwest coast of Ireland and England, Cape of Good Hope, etc."

The heaviest rainfalls in the world occur where there is a combination of these causes, viz.: where the prevailing wind blows off the sea and is forced upward by high mountains near the coast.

"The following are some of the causes of deficient rainfall:

"1st. A nearly uniform direction of the wind throughout the year, such as prevails within a portion of the system of the trade winds, especially in mid-ocean, and to some extent over the continent, *e. g.*, Ascension Island, the Sahara, Southern California, South Africa and Australia.

"2d. The prevalent wind, having passed over a range of elevated mountains, descends upon the leeward side, *e. g.*, desert of Gobi, Tartary, Chili, North America east of the Rocky Mountains, central portion of Spain, etc.

"3d. Ranges of mountains so situated as to obstruct the free movement of the surface winds toward a central region, *e. g.*, desert of Gobi, Tartary, Southern California, Salamanca in Spain, etc.

"4th. Remoteness from the ocean, measured in the direction from which the prevalent wind proceeds. There is a marked diminution in the mean annual rainfall as we advance eastward from Western Europe. A similar effect is noticeable in many other parts of the world, but it is generally complicated by the combination of other causes.

"5th. High latitude. Beyond the parallel of 60° N. lat., at a little distance from the ocean, the mean annual rainfall seldom much exceeds 10 inches; and there are apparently regions of great extent in Asia and North America where the annual rainfall is less than 10 inches."

Temporary Excessive Rainfalls in the United States.

In his sixth and seventh papers, Loomis studied the temporary abnormal rainfalls of the United States. In his sixth paper he selected all those cases during a period of fifteen months (Sept., 1872, to Nov., 1873) in which at least two inches of rain fell in eight hours at any one of the Signal Service stations. "These cases were then divided into two classes, one containing the stations south of latitude 36°, and the other containing the stations north of latitude 36°." He first tabulated the cases south of lat. 36°; then drew on maps of the United States the curves of equal rainfall for each fourth of an inch. "These curves show that when there is only one principal center of precipitation, the form of the rain area is nearly circular, and its diameter varies from 350 to 750 miles. . . . . These excessive rainfalls are not of long continuance, but their exact duration cannot be determined from the observations. In two cases over two inches of rain fell in two successive periods of eight hours at the same station; and in a few other cases these great rainfalls were followed during the next eight hours by a fall of one inch or more, either at the same station, or at a station a little to the eastward. . . . . Near the coast great rainfalls occur twice as frequently as they do at stations in the interior at a distance of 200 miles from the coast. . . . . The depression of the barometer attending these rainfalls was generally small; nevertheless, in several cases it was quite appreciable.

. . . . . In about half of the cases there was an area of low barometer prevailing in the northern portion of the United States, and about as frequently there was an area of high barometer on the northern side of the station. These conditions appear to be about equally favorable to heavy rainfalls. The distribution of the 52 cases by seasons was as follows: Spring, 8; Summer, 14; Autumn, 14 and 12; Winter, 4. We thus see that rainfalls are most frequent when the heating effect of the sun's rays are greatest and the atmosphere contains the greatest amount of vapor. The distribution of the cases according to the hours of the day was as follows:

At the 7:35 A. M. obs., 19 cases.
" 4:35 P. M. " 25 "
" 11-00 P. M. " 8 "

The intervals between the observations, which I have for convenience called eight hours, are in fact unequal. Making, however, due allowance for inequality of intervals, it seems clear that in the United States, south of latitude 36°, heavy rainfalls are less frequent from 4:35 P. M. to 11 P. M. than during the remainder of the day."

The following are the results of the study of the cases of excessive rainfall in the north:

"North of latitude 36° great rainfalls generally occur within 250 miles of a center of low pressure, and almost invariably on the east side of the low center. . . . . The rain occurs as frequently in the northeast quarter from the low center as it does in the southeast quarter. . . . . North of latitude 36°, near the Atlantic coast, great rainfalls are *five times* as frequent as in other parts of the United States in the same latitude. The frequency of heavy rainfalls in the neighborhood of the great lakes is not sensibly greater than at inland stations quite distant from the lakes.

The distribution of the 31 cases by seasons was as follows:

Spring, 3; Summer, 15; Autumn, 6 and 5; Winter, 2. Showing a predominance of great rainfalls in summer even more decided than at the southern stations.

The distribution of these cases according to the hours of the day was as follows: 7:35 A. M., 14 cases; 4:35 P. M., 9 cases; 11 P. M., 8 cases. If we correct these numbers for the inequality of the time intervals, there is still an excess of cases for the morning hour of observation." [This predominance of heavy rainfalls in the morning is rather peculiar since Loomis found in his third paper that hourly records of the rainfalls at Philadelphia, when averaged, showed a decided maximum about 6 P. M. and a minimum about 3 A. M., the maximum being more than two and a half times the minimum.]

"At the southern stations, out of fifty-two cases of heavy rain there were twelve cases in which heavy rain continued through two periods of eight hours; at the northern stations, out of thirty-one cases there were thirteen which continued through two periods, indicating that heavy rains are of longer duration at the northern stations than they are at the southern. . . . . Both at the northern and southern stations heavy rains are generally accompanied by easterly winds. At the northern stations southeast winds are most prevalent, while at the southern stations northeast winds are most prevalent. . . . . In a large number of cases the observations show that a southeast wind at certain stations was opposed by a westerly or northerly wind at other stations. This opposition or interference of winds generally results in a cycloidal [cyclonic] movement, and the observations clearly indicate such a movement in nearly all the cases in the table. . . . . When the rain was remote from the center of low pressure this cyclodal movement was local and limited to a small area and did not generally exert a decided influence upon the isobaric curves."

In his seventh paper, in order to eliminate what error might arise from local influences at single stations, Loomis examined all of the cases from Sept., 1872, to Nov., 1873, in which the *total* rainfall for eight hours at *all* of the stations of the U. S. Signal Service was unusually great, viz.: eight inches or more.

"The form of these rain areas is sometimes quite irregular, but generally it approximates to an ellipse of which the major axis is not quite double the minor axis. This elongated form of

rain areas is more noticeable in storms which prevail near the Atlantic coast, than it is in regions remote from the ocean. . . . . During heavy rainfalls the wind generally blows from some quarter between south and northeast, or if it blows from any other quarter its velocity is quite small; but occasionally a great rainfall occurs with a strong wind from some quarter between north and southwest, and in such cases it is presumed that at the same time an easterly wind prevails at those places as an upper current. . . . . The movement of this upper current can sometimes be seen. . . . . The heaviest rainfalls are seldom accompanied [at the place of precipitation] by very high wind. . . . . The table shows that great rain areas are seldom of long continuance. In twenty-three cases the same rain area continued for at least two periods of eight hours; in seven cases it continued for at least three periods; and in only two cases did it continue for more than three periods, that is, twenty-four hours. . . . . The center of great rain areas is found near the Atlantic coast *four times* as frequently as it is in the other portions of the United States. . . . . The distribution of the 55 cases by seasons was as follows:

Spring, 8; Summer, 9; Autumn, 10 and 16; Winter, 12, showing a slight predominance of great rain areas in autumn and winter. In my last paper it was shown that excessive rains at single stations were most common during the warmest months; but it appears that very extensive rainfalls are most common during the cooler months. The distribution of these cases according to the hours of the day was as follows: 7:35 A. M., 25; 4:35 P. M., 22; 11 P. M., 8. After correcting these numbers for the inequality of the time intervals, we still find that from 4:35 to 11 P. M. great rainfalls are *not half as frequent* as during the remainder of the day. This result is quite similar to that found in my last paper with regard to great rainfalls at single stations south of latitude 36°."*

* The present writer found from his own observations in Michigan and Tennessee that the per cent. of cloudiness at 9 P. M. was decidedly less than at 7 A. M. and 2 P. M., but it does not seem to be so in Massachusetts.

Temporary Deficiency of Rainfall in the United States.

During the fifteen months from Sept., 1872, to Nov., 1873, Loomis found 101 cases in which the rainfall did not amount to one-tenth of an inch in eight hours at any of the Signal Service stations, and in eight of these cases no rainfall was reported from any station.

Coincident with many or most of these cases there existed in the United States well defined areas of both maximum and minimum pressure.

"The distribution of these cases according to the season of the year was as follows: Spring, 14; Summer, 4; Autumn, 39 and 21; Winter, 23. We see that these cases occur most frequently in the autumn, and especially in the month of October. They are generally accompanied by a hazy or smoky condition of the atmosphere, and this is the phenomenon which is generally known under the name of *Indian Summer.* It appears to be due to an uncommonly tranquil condition of the atmosphere extending entirely across the continent; and similar cases frequently occur in each month of the year from September to March, but are most common in October.

Relation of Rain Areas to Areas of Low Pressure in the United States.

In his seventeenth paper Loomis selected from the published volumes of the U. S. Signal Service and tabulated "all the cases from Dec., 1873, to Jan., 1875, in which the total rainfall at all of the stations amounted to at least nine inches in eight hours; also all the cases from Jan., 1877, to June, 1877, in which the total rainfall amounted to at least ten inches in eight hours; and for July and August, 1877, amounted to eleven inches in eight hours. This change in the amount of rainfall adopted as the standard was rendered necessary by the gradually increased number of the stations of observations."

"For each of the cases named in this table, the curves of one half inch rainfall, and also of one inch rainfall, were carefully drawn upon the Signal Service maps. . . . . One of the most noticeable facts connected with these great rain storms is the

large number of rain-centers prevailing simultaneously, and often quite distinct from one another. . . . . The table shows one case in which there were seven rain areas exceeding a half inch in amount; it shows six cases in which there were as many as six such areas; fifteen cases in which there were as many as five such areas; twenty-seven cases of four such areas; forty-eight cases of three such areas; and only nine cases in which there was not more than one rain area in which the rainfall exceeded half an inch. Indeed, if the stations of observations were sufficiently numerous, it is quite possible they would show that in every one of these storms there was more than one rain area amounting to half an inch. This multitude of rain centers appears to be intimately connected with the complex character of most storms. If we compare the principal rain centers of these storms we shall find that their average distance from the center of low pressure is very nearly 400 miles." In order to clearly show the relation of these rain areas to areas of low pressure a transparent piece of paper was divided by cross lines into quadrants; then placed in succession with the cross lines running north to south and east to west over each center of minimum pressure; and the position of the rain centers was plotted in their proper position as regards the center of low pressure, at the same time distinguishing the minor from the chief rain areas. A composite or average of a large number of storms was thus formed with the rain areas in their proper relative positions. "An inspection of this plate shows that there is a marked predominance of rain centers on the east side of the low center, and that they occur most frequently in the northeast quadrant. In the following table, column second shows, for each of the four quadrants, the total number of rain areas in which the rainfall amounted to at least half an inch; and column third shows the number of cases in which the principal rain center was found in each of the quadrants."

Quadrants.	Rain Centers.	
	Half an Inch.	Greatest.
Northeast	86	31
Southeast	71	27
Southwest	41	9
Northwest	18	1

". . . . . We find that during the entire period of the published tri-daily observations (37 months), if we exclude the cases in which the rain center was more than 500 miles south of the low center, there were but six cases of great rain storms in which the principal rain center was southwest of the low center, and in each of these cases the lowest isobar formed an oval whose longest diameter was from three to five times its shortest diameter, and the longest diameter was directed towards the northeast. The principal rain center appeared to be in the southwest portion of the oval; but at the same time there prevailed in the northeast portion an area of rain of less depth but of equal, or greater, geographical extent. . . . . We also find four cases in which the rain center was northwest of the low center. In three of these cases the low center advanced toward the northwest. In the other case, although there was a station on the west side where the rainfall was .07 inches greater than at any station on the east side, the rain area on the east side was much the greatest in geographical extent, and the area of low pressure moved slowly eastward."

"The comparison of the three years' observations shows us that although considerable rain attends all great storms, or areas of low barometer, and these areas of low barometer can sometimes be traced through a distance of many thousand miles, yet the rainfall in such a storm does not form a regular rain belt of many thousand miles and of nearly uniform breadth, but rather a succession of rain areas grouped irregularly together. The continuity of the belt may not be absolutely broken, but its breadth and density exhibit great irregularities. While a storm is pursuing its path from the Rocky Mountains to the Atlantic Ocean, the breadth of the rain belt may vary from 100 or 200 miles to 1,500 miles; and the amount of rain near the central line of the belt may vary from four to five inches to less than one-tenth of an inch. . . . . In all of the cases . . . . . the rainfall west of the meridian of 100° was well nigh inappreciable, and the rainfall increased rapidly as the low area moved eastward. Whenever there was a heavy rainfall west of the meridian of 85°, the rain almost invariably declined

before reaching the Atlantic coast. The heavy rainfalls near the Atlantic coast generally commence in the south and follow the Atlantic coast towards the northeast."

"The high winds which are uniformly found to prevail somewhere in the vicinity of a great fall of rain deserve particular notice. In my seventh paper the average velocity of the wind at the stations of greatest rainfall was found to be only ten miles per hour, but in each case there was within the low area some station where the wind attained a much greater velocity. . . . . There was no instance in which the wind did not attain a velocity of sixteen miles per hour at some one of the stations within the low area. . . . . In 53 of the cases the velocity rose as high as twenty-five miles per hour; in sixteen of the cases it rose to forty miles per hour; and in three cases it exceeded sixty miles per hour. These high velocities come from all points of the compass but most frequently from the south and northeast. The southerly winds are slightly stronger than the northerly winds, and the easterly winds are decidedly stronger than the westerly winds. The most remarkable feature of the winds attending a great fall of rain is their very unequal force at stations not very remote from each other. . . . . It seems difficult to explain these observations except by admitting that near the station where the wind attained its greatest velocity, there was a strong upward movement of the air, and that the void thus left in the lower stratum of the atmosphere was supplied by air flowing in with a smaller velocity from a much greater geographical area. . . . . We frequently find the winds blowing exactly toward each other, from stations less than 100 miles apart. Generally such winds are feeble, but occasionally they are very strong, and in such cases we generally find that rain is falling in that vicinity."*

Relation of Heavy Rainfalls to Areas of Low Pressure in Europe.

"In order to prosecute this enquiry under different geographi-

* These observations show very clearly that the heaviest rainfalls attend the smaller secondary storms which are developed within the area of, or the vicinity of, larger storms.

cal influences, I have prepared tables showing for a series of years the principal rainfalls in Europe. I selected from the Bulletin of International Meteorological Observations all of those cases in which a rainfall of two inches in twenty-four hours was reported from any station during the years 1878, 9, and 80. These cases are 233 in number." From a study of the cases were deduced the following conclusions:

"1. Cases of very heavy rainfall in Europe almost invariably occur within or near an area of low pressure, but a great rainfall is frequently due to a local cyclone of moderate extent formed within or near a large area of low pressure. . . . . Whenever a movement of the winds about a center of low pressure is feeble, there frequently results a local disturbance attended by a cyclonic motion of the winds and a considerable precipitation of vapor; and this is generally associated with a subordinate area of low pressure which sometimes extends and attains considerable magnitude. In many cases this precipitation of vapor appears to be due to the influence of mountains by which the air when set in motion is deflected upward.

"2. These rainfalls most frequently occur on the east side of an area of low pressure. In 1879, the cases in which a heavy rainfall occurred on the east side of a low centre, were nearly six times as numerous as those on the west side; and even if we count all those cases marked N. or S., as having occurred on the west side of the low center, we shall still find the cases on the east side to be nearly four times as numerous as those on the west side.

"3. Nearly four-fifths of the cases enumerated in the table occurred at stations south of lat. 48°, so that the conclusions above stated apply primarily to southern Europe, and we can not fail to notice a marked correspondence between the effects of a heavy rainfall in southern Europe, and in the southern part of the United States. In both countries the influence of a great rainfall upon a center of low pressure is generally not very decidedly marked; while in the northern part of the United States, this influence is generally quite obvious and decided. In the United States, the parallel of 36° gen-

ally forms a satisfactory dividing line between these two classes of cases; but in Europe this dividing line is found in a much higher latitude, perhaps near the parallel of 48°. I have made an extensive collection of cases of heavy rain in Europe, north of this parallel, and have found a close correspondence with cases of heavy rain in the United States, north of the parallel of 36°. For the year 1880, in Northern Europe (employing all cases in which the rainfull amounted to as much as one inch in twenty-four hours), the rain-center occurred on the east side of the center of low pressure more than four times as frequently as it did on the west side; the rain-center was found in the northeast quadrant as frequently as in the southeast quadrant; the cases of one inch rainfall in the northwest quadrant were only three in number, and in neither of these cases was the rain center distant from the center of low pressure more than 150 miles. For all the cases in 1880 in northern Europe, the average distance of the rain-center from the center of low pressure was 420 miles, and the average pressure at the center was 740 milimeters, or 29.13 inches." H. HELM CLAYTON.

BLUE HILL OBSERVATORY MARCH 30, 1887.

[*Concluded*]

POPULAR ERRORS IN METEOROLOGY.

[CONTINUED.]

A singular belief has been handed down to us from remotest ages, to the effect that the animals in their natural state, know more about the future weather than does man himself, and this idea has apparently grown out of the study of the habits of migratory birds and hybernating animals, all of whom do seem to foresee the approaching seasons at least in a general way; it certainly has required the best power of the speculative naturalists to explain how such birds, for instance, as the wild duck, or the swan, ever came to think of making their long annual flights. We see the Indian go from the sea shore, and a marine diet, in winter, to the forests and flesh diet in the summer (or we see the modern American reverse this process), and we are

not surprised, as we attribute it all to the intelligence of human beings, the necessities of their organization and the stress imposed by the changes in the season. Why, then, ought we to be surprised to find that the modern naturalist says that the migratory bird similarly inherits a gradually increasing amount of knowledge from his ancestors, that he has intellectual development any more than has the white man? The migrations and the hybernating habits are, therefore, the result of the experience and teachings of many past ages, beginning with the glacial epoch, and producing a habit of life in an intelligent animal to which he persistently adheres. It is not necessary to suppose that the Creator has given these animals a deeper knowledge of meteorology than has been given to human beings. He who consults the habits of the ground-hog, the crow, the spider, the wild geese, or the goose-bone, or the hundred other animals concerning which there are hundreds of rules in books of weather wisdom, is trusting to the intelligence of animals who are less intelligent than himself, and is neglecting to cultivate those faculties and habits of observation and reasoning with which his Creator has endowed him for the very purpose of getting at the mysteries of Nature and utilizing the powers to his own benefit. In other words the meteorologist would say there is scarcely any truth in the idea that all these mute creatures have for self-preservation been fitted with what to us is an unknown sense, informing them of minute changes in the atmosphere long before the coming of the danger. They have either acquired their habits, as other intelligent creatures do, from experience and reason, or they are wholly guided by natural causes beyond their control.

[CONTINUED.]

GAS COMETS.

Although not in the gas region, the phenomena described under the above title, in the Journal for February, are frequently observed here as an accompaniment of small prairie fires. I have never seen any as large as those described by Col. Roberts, but in all other particulars, the agreement is quite complete.

The conditions necessary do not here include a very low temperature. I do not remember having seen one on a perfectly clear night, neither do they occur on very cloudy nights, but rather when the air is a little hazy or misty, with few clouds and little wind. I have not noticed the preceding sunsets.

Their general appearance is quite comet-like,—lacking the nucleus. Only once have I seen any but vertical lines of light; that was about two years ago on a warm April night. The appearance was that of a small stratus cloud with two parallel "pillars" standing up from it at an angle of about 75°. The "pillars" were of nearly equal height and seemed to be similar to the horizontal band, which I have likened to a cloud, but which I did not think at the time was a cloud.

Another feature of the prairie fire may be worthy of note. On clear, cool days, when there is little wind, the column of smoke rising from the fire, will be seen to terminate in a fleecy white cloud.

A very fine example of this mode of cloud formation, occurred near here on the 21st of March last. The conditions were as follows: Light breeze from the north; cirrus clouds here and there in all quarters save the east, where there were a few cumulo-stratus; a rather bright halo of 22°; temperature 45°; time 1:30 P. M. The fire was distant about three miles S. E. The ascending column of thin brown smoke, at the height of from one-fourth to one-half a mile seemed to change into a dense cumulus cloud, the white fleecy mass rolling up, a veritable "thunder-head" of good proportions,—miles away from any other cloud. The fire lasted but a few minutes, and as soon as the heat slackened the cloud settled down and was rapidly dissipated in the warmer strata below.

One day about a year ago, a dozen such phenomena were visible at the same time, all some seven or eight miles distant.

The explanation is obvious. G. E. C.

VERMILLION, DAKOTA, April 13, 1887.

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